

# Capacity building in rural Guatemala by implementing a solid waste management program

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## Abstract

The development and implementation of a solid waste management program served to build local capacity in San Mateo Ixtatán between 2002 and 2003 as part of a public health action plan. The program was developed and implemented in two phases: (1) the identification and education of a working team from the community; and (2) the completion of a solid waste classification and quantification study. Social capital and the water cycle were two public health approaches utilized to build a sustainable program. The activities accomplished gained support from the community and municipal authorities. A description of the tasks completed and findings of the solid waste classification and quantification performed by a local working group are presented in this paper.

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## 1. Introduction

During a town-hall meeting in April 2002 arranged by the Ixtatán Foundation, representatives from eight neighborhoods of the urban area of San Mateo Ixtatán, a predominantly rural municipality in Guatemala, identified three main problems affecting their health and development:

- (1) drinking water quality;
- (2) solid waste management; and
- (3) wastewater management.

A representation of the local water cycle at the meeting served to illustrate how those problems might be linked and community representatives supported the idea of planning an intervention (Zarate, 2002a). A public health action plan for the town was designed, which included pro-

grams for the management of drinking water quality and solid waste. The plan was presented in June 2002 (Zarate, 2002b).

The development and implementation of these programs required two educational phases. Phase 1 was a short course on the basic principles of drinking water quality and solid waste management (SWM). The course included a practical component with sanitary surveys of both drinking water supply systems and sites around the market where solid waste accumulated. Surveys at the sites where solid waste was disposed consisted of demonstrations on waste classification. Phase 2 consisted of a set of hands-on activities to reinforce the knowledge and skills that students had been acquiring through the short course. This phase included the classification and quantification of solid waste. A description of this experience and the findings of the solid waste classification and quantification are presented in this paper.

Municipal solid waste management (MSWM) is a major responsibility of local governments. It is a complex task, which requires adequate organizational capacity and cooperation between numerous stakeholders in the public and

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private sectors and relies upon appropriate technical solutions. Municipal solid waste management services include collection, transfer, treatment, recycling, resource recovery, and disposal of waste from urban areas. In most cities of developing countries, MSWM services primarily include waste collection, transfer, and disposal. In rural areas, these services are rare and, if they exist, are reduced to collection and disposal. Notwithstanding, these services are inadequate: a significant portion of the population does not have access to a waste collection service and only a fraction of the generated waste is actually collected. In addition, final disposal of solid waste is commonly at open dumpsites. However, people expect that the service occurs regularly and that it is managed appropriately, especially when it is taxed (Dijkema et al., 2000).

In the last decade, different authors have stated that the implementation and development of waste management programs that ignore social aspects are doomed to fail (MacDonald, 1996; Joos et al., 1999; Dijkema et al., 2000; Morrissey and Browne, 2004; Henry et al., 2006). Social aspects concerning decision transparency, networking, cooperation and collective action, communication and information, public participation and empowerment are key elements of social capital (Grootaert et al., 2002). They can be used to enhance the public's acceptance of waste management. The people in San Mateo Ixtatán were familiar with these social aspects. In fact, they used them during the development and implementation of the solid waste management program. Problems such as illiteracy, unemployment, and poor public health infrastructure are known to block social development, but people in San Mateo Ixtatán acknowledged and showed a strong will to overcome them. For example, at the time of program implementation community members helped to build a secondary school, which they never had before. According to UNICEF (2006), approximately 58% of municipalities in Guatemala have a secondary school.

In the 1990s, Guatemala implemented new policies aimed to protect the environment and to fund projects for the sound management of natural resources (Guatemalan Government, 1997, 1998, 2005). These new policies directed resources to address environmental pollution issues and improve the coverage of basic services, including solid waste management and environmental education in school curricula. A report on the country's environmental quality guided the principles for institutional strengthening, which included capacity building through improved communication and social participation (Guatemalan Government, 2001). Another goal of the government was to decentralize the administrative, economic, political and social powers of the executive branch to municipalities with the principle aim to increase citizen participation (OAS, 2002). However, some rural municipalities, among them San Mateo Ixtatán, lacked the economic and human resources required to implement those policies.

When compared to Guatemala, the concept of SWM in the US changed since the enactment of the Resource

Recovery Act in the US in 1970. The practice of SWM in Guatemala focuses on disposal, while in the US, it shifted from disposal to recycling and reuse of recoverable materials and generating energy from waste (Sharma and Lewis, 1994). Recycling developed over years and together with composting activities in 1999 prevented about 64 million tons of material from ending up in landfills and incinerators in the US. Today 32% of the waste in the US is recycled countrywide, a rate that has almost doubled during the past 15 years (US EPA, 2007). Energy recovery was also applied as fuel recovery for co-combustion. Initial studies focused on emissions from the combustion of refuse-derived fuel with coal (Norton et al., 1986; Norton and Levine, 1989; Norton, 1992) and evolved to full-scale combustion in a circulating fluidized bed boiler (Campbell et al., 1993). In addition, some cities started to develop and implement integrated SWM programs (Diaz et al., 2002). This shift in US management of solid waste motivated the development and implementation of novel SWM programs elsewhere (Tanaka, 1999; Hosoda, 2000; Kim, 2002), and some authors paid attention to the situation in developing countries (Shimura et al., 2001).

In recent years, MSWM in developing countries has attracted increasing attention from bilateral and multilateral development agencies, due to the mounting urgency of urban environmental problems and increasing concern for capacity building at the level of municipal management. However, in spite of the million-dollar loans and grants that developing countries have received to improve the basic services sector, including SWM, the lack of suitable qualified human resources contributed to the inability of municipalities and communities to implement new projects. This is evident in Guatemala, a country that suffered a civil war that lasted over 30 years, destroying much of the infrastructure and leaving thousands of people dead or having left the country (USIPL, 1998). Therefore, sectors such as SWM have been severely weakened in the urban and rural areas of the country.

### 1.1. Purpose and objectives

The purpose of this project was to implement the solid waste management program and address one of the public health needs identified by community members. The main objectives were the following:

- (1) to teach a short course on the basics of solid waste management; and
- (2) to conduct hands-on activities for solid waste classification and quantification.

## 2. Methodology

The SWM program, as part of the public health action plan, was designed between April and June 2002 for the urban area of the Municipality of San Mateo Ixtatán that

had a population of 10,000 inhabitants distributed in eight neighborhoods (Ramos, 2002). The SWM program was presented to each neighborhood of San Mateo Ixtatán, and the two phases, the short course and the hands-on activities, for its implementation were explained. Each neighborhood nominated representatives to attend the course, in addition to students from the middle school. Thus the community played an integral role in the development and implementation of the SWM program. The program incorporated elements of social capital with the principle aim to build a trusting and lasting relationship with the community. This was important because the civil war did not only destroy the infrastructure but also created a lack of trust of outsiders or people with authority. The first phase to implement the program included a short course on the principles of SWM. In the second phase, hands-on activities for the classification and quantification of the waste stream were conducted in a dumpsite outside the market. This site was selected because most waste in homes was burned in their cookstoves or backyards, or was dumped along the roads outside the town. Thus the selected dumpsite was the only source of waste that was accessible and not partially burned before it could be analyzed. As people bought a majority of their produce in the market, the composition at the site was similar to waste produced in homes. However, it only represented a small fraction of the entire waste produced in San Mateo Ixtatán.

## 2.1. Implementation of the SWM program

### 2.1.1. Phase I. Short course

The objective of the short course was to provide participants with a basic understanding of solid waste management. It therefore included a series of theoretical lessons and practical tasks. The short course was planned for a period of two weeks. The lessons planned for the first week covered theoretical aspects of addressing the problems affecting health and development in San Mateo Ixtatán, particularly as it relates to solid waste mismanagement and drinking water quality. By the middle of the second week, students formed two working groups, one on drinking water quality and the other on solid waste management. Practical tasks were planned for the second week, and those for the solid waste management working group included the following:

- Sanitary surveys of dumpsites: these activities were carried out in sites near the market where solid waste was dumped and that served to identify the potential sites of contamination of water streams and the risk of children's exposure to harmful agents contained in solid waste.
- Demonstrations of solid waste classification: these activities were very important in the educational process and were carried out at a site identified by members of the working group. They served to educate participants on how to separate the types of waste produced at the mar-

ket, the weight/volume relationships and their influence on transportation and final disposal, and the different benefits of doing waste sorting and separation (e.g., recycling, reusing, composting).

- Identification of a new temporary dumping site for solid waste: this activity took some time because of the need for a SWM consultant who could help in the location of the site, which occurred in January 2003.
- Discussions with municipal authorities to collaborate with the program: this was a lengthy process because municipal authorities initially showed no interest in the SWM program, but the growing involvement of the community in the activities that were being carried out and the identification of the temporary dumping site motivated the municipal authorities to collaborate.
- Creation of networks of collaboration with local entities: this activity served to start collaborating with governmental and non-governmental officials whose work was on education, health, and development programs in San Mateo Ixtatán, as well as to gain contacts at regional and national levels.

The practical tasks that were part of the short course continued for 6 months and served to hone the skills of members of the working group on solid waste separation and classification. They also served as transitional activities while phase two of the program was being planned.

### 2.1.2. Phase II. Hands-on activities

The objective of the hands-on activities was to apply the knowledge acquired in the course to conduct a solid waste classification and quantification study. Standard methods for waste classification and quantification were not followed for the following two reasons:

- (1) this was the first effort in a remote area of Guatemala where motivated community members took great initiative in learning the basics of SWM and implementing the program; and
- (2) there was a lack of resources and laboratory infrastructure to conduct most of the standard determinations.

Members of the community and friends of the Ixtatán Foundation visiting San Mateo provided assistance in this activity on varying dates. These activities were accomplished during the period June–August 2003.

1. *Solid waste classification:* These activities were performed by members of the solid waste working group, which included seven neighborhood representatives and five middle school students. They selected the dumpsite near the market to classify and segregate the different types of solid waste, weigh them, and estimate their volume. Members of the working group learned to use weight/volume relationships and their importance in

transportation and final disposal. They understood, for example, that recycling and/or composting portions of the waste resulted in both total volume and weight minimization with the corresponding reduction of the SWM costs. Activities were conducted on three Thursdays and Sundays after the market closed. The site was an open area of approximately 0.84 m<sup>2</sup> with dimensions of 1.2 m × 0.7 m (9.06 ft<sup>2</sup> or 3.94 ft × 2.30 ft). Waste was sorted or separated into the following fractions: organic wastes, which included fruit and vegetable wastes, and rubbish that included plastic bags, wrappers, cardboard, plastic bottles, cans, mixed paper, and glass. Fruit wastes are limited mainly to banana peels and apple cores (denser fruits are largely unavailable in San Mateo Ixtatán), and vegetable waste varied. Fractioning solid waste was based on the classification by Peavy et al. (1985). The hands-on activities consisted of separating waste into different categories and placing waste into large black plastic trash bags. The moisture content of waste, although important for quantifying weight, was not determined in San Mateo Ixtatán because there was not a laboratory available or accessible. Ash and dirt that remained at the site after separation were discarded. Ash was usually generated by neighbors burning waste, which contained mixed paper, and dirt and was collected during sweeping of waste from the market's soil.

2. *Solid waste quantification:* Once wastes were separated into bags, they were weighed using the merchandise scale from a nearby store ("Tienda San Pablo"). The owner of the store assisted throughout the entire second stage by lending his scale to weigh the wet wastes. The scale was placed on a level surface, calibrated to zero without a bag on it and weights recorded in pounds and ounces. The volume of the waste was estimated by use of a tape measure. Then weight/volume relationships were determined. Wastes in the bags were compressed using hands and/or feet to release as much air as possible before the dimensions were measured. The methods used were not typical for weight and volumetric determinations of solid waste. Members of the working team modified the methodology based on the resources available and the experience they were gaining with the process. After completing those activities they learned that manual compression may substantially reduce the volume of waste and that mechanical compression would reduce it even further. The working team members also learned that the volume and weight of waste can also be reduced through recycling and composting. Composting was an activity that people in San Mateo Ixtatán practiced with waste generated during food preparation, which was piled up in trenches of their backyards. Density was calculated for each waste category and the knowledge gained on the weight/volume relationships as it pertained to collection, transportation, and disposal of solid waste was reinforced.

### 3. Findings and discussion

San Mateo Ixtatán is divided into the urban and rural areas. The implementation of the solid waste management program took place in the urban area (population of 10,000 at the time of the study). The eight neighborhoods in this area had houses that ranged from 90 to 300 in number (Ramos, 2002), with a weighted-average population density of 7.35 inhabitants per household (Table 1).

#### 3.1. Phase I

##### 3.1.1. Short course

The course was taught in the evening, for 2 h. Although students who attended it had other obligations during the day, their interest in learning the basics of drinking water quality and solid waste management was a great motivation. The course started with approximately 20 participants and ended with almost 30, which indicated that the entire community was highly motivated. Members of the solid waste working team had an active participation in the course and listed the location of four commonly used dumpsites in San Mateo Ixtatán.

##### 3.1.2. Practical tasks

Sanitary surveys were conducted in the dumpsites, which helped team members to identify and visualize potential routes of human exposure to solid waste and their associated risks. The main observations that members of the team were asked to record were: (1) location; (2) children's activity; and (3) scavengers' activity. Four sites were most commonly used to dump wastes; three were located around the market and one along the perimeter of the elementary school. Two were located near water streams, one of which was the main dumpsite of town that was found to be located across from the drinking water distribution tank of the largest neighborhood in town, Yolwitz. Activities of children and animal scavenging were frequently reported at

Table 1  
Neighborhoods of the urban area of San Mateo Ixtatán and corresponding estimated number of households and population in 2003 (Ramos, 2002)

Neighborhood	Number of households	Population	People per household
Las Cruces	120	800	6.67
Yawa and Nihuanamac	250	1800	7.20
Yolwitz	300	2200	7.33
Yunechonab	215	1500	6.98
Chakchaken	160	1200	7.50
Chichjoj	100	750	7.50
Caxepa Centro and Caserio Caxepa	125	1000	8.00
Oxetaj	90	750	8.33
Total	1360	10,000	
Average			7.35



this site. Upon completion of the sanitary surveys, a class was taught on the local water cycle to help members of the working team realize that solid waste mismanagement has the potential of contaminating surface water, ground-water, and drinking water distribution systems. This class provided more detail than the representation of the local water cycle that was used during the town-hall meeting held in April 2002.

The main dumpsite was located next to the east wall of the market, which is across from the drinking water distribution tank of Yolwitz. Solid waste had been disposed there for more than 5 years, and it began covering up the path leading to the tank. During the sanitary inspection of the site, the team observed pigs scavenging and spread excrement, which increases the risk of contaminating drinking water in the distribution system of Yolwitz. The vulnerability of this system was demonstrated by the drinking water quality intervention study (Zarate et al., unpublished data) that was based on recommendations by Lloyd and Helmer (1991).

### 3.1.3. Transition to hands-on activities

It took almost 9 months of working in San Mateo Ixtatán to convince municipal officials and the Mayor of the importance of the public health action plan. Their interest increased further once they were presented with the findings from the sanitary surveys that had been conducted. The Mayor then scheduled several meetings with members of the working team, and his collaboration increased further after a SWM consultant visited San Mateo Ixtatán and helped in the identification of a new temporary dumpsite. He designated a site that was located almost 4 km (2.5 mi) away from town and had a series of natural soil depressions near a road in a hilly area free of springs. Now a truck was needed to transport solid waste to the new temporary dumpsite at least twice a week, on Friday and Monday mornings after market days. The Mayor offered his personal truck to carry out that task and municipal officials started to collect solid waste dumped in open areas near the market and to transport it to the new temporary dumpsite for final disposal. Also, they applied their knowledge of compaction, learned from members of the SWM working team, using their hands, feet, and tools such as shovels, each time space was needed to transport more solid waste.

### 3.1.4. Networks of collaboration

In order to make the public health action plan sustainable, the team contacted as many agencies as possible such as institutions working at local, regional, and national levels. At the local level, contacts were made with representatives of the Ministries of Education and Health, as well as representatives of development organizations working in San Mateo Ixtatán. Among them were: representatives of CECI/AID (Canadian and US International Aid Agencies) and PAFMAYA (a non-governmental organization working on forestry projects with US funding). Activities, such as designing and implementing a solid waste management

campaign in the schools of San Mateo, were agreed upon with local teachers and the Ministry of Education representatives.

Our collaborative links also included government and non-governmental agencies at the regional and national levels. Academics of Guatemalan universities conducting health and development projects were contacted, and they also gained interest in the program.

## 3.2. Phase II

The objective was met for the hands-on activities, which included classification and quantification of solid waste. These activities took 3 months (June–August 2003). The fractions of wastes found in San Mateo's market are typical components of market wastes found elsewhere (Sharma and Lewis, 1994). Table 2 presents a summarized description of the waste classification.

The data collected showed that on average more garbage was generated on Sundays than on Thursdays. In addition, a great variation was noted in the overall production of waste from one week to the next. Also, wastes collected from the San Mateo market varied not only in volume and weight, but also in type. This variation in waste types seemed to correspond with the diversity of products found in the market and with some specific characteristics of the waste constituents such as resistance to compaction and moisture retention. The findings presented in the figures below are averages of waste composition by weight, volume, and density. All waste collected in the market was assessed and only a minor percentage, probably much less than 5% in weight, mainly ash and dirt, may not have been assessed for lack of ability to remove it from the ground or classify unknown waste. A more detailed presentation of similar variations, but focused on organic wastes, is given below. Variation of average weight of solid waste components and their percent contribution during the period when data were gathered are shown in Fig. 1. Organic waste, mainly composed of fruit and vegetable

Table 2

Categories and sub-categories of solid waste that were disposed and collected during market days in San Mateo Ixtatán between July and August 2003

Category	Description
Organic waste	Biodegradable organic matter (e.g. vegetable and fruit wastes)
Rubbish	
Sub-category	
Plastic bags	Flexible packaging made of thin plastic film
Wrappers	From snack foods, most made using cellophane and some with thin aluminum foil
Cardboard	Packages from goods commercialized in the market
Plastic bottles	Containers of soft drinks
Cans	Containers of canned drinks (aluminum and tin) and food (tin)
Mixed paper	Newspaper mixed with white and colored paper
Glass	Glass containers and broken glass

wastes, was always the primary constituent by weight and averaged 25.27 kg, which represented 65.33% of the average weight of solid waste dumped at the selected dumpsite during the study period. Cardboard boxes were the second constituent of importance followed by glass, plastic bags, and mixed paper. The average weight of cardboard boxes was 5.69 kg, representing less than 15% of the total average weight of solid waste. The average weight of glass was 2.23 kg, representing 5.78% of the total average weight, while each one of the remaining fractions represented less than 5% of the total average weight. Members of the working team were engaged even more in their tasks after showing graphic illustrations of the classification and quantification of solid waste. The graphs also helped in realizing the amount of weight that could be reduced if some of those wastes are recycled, reused, or recovered instead of being disposed.

The variation in composition of solid waste might have been influenced by differences in ash, dirt, and moisture content. Burning, as well as sweeping, solid waste was common in the market of San Mateo Ixtatán before collecting and dumping it. Also, traditional practices and cultural values of people in the town have influenced their con-

sumption habits. The latter influenced the variations observed in the classification and quantification of solid waste in San Mateo Ixtatán. The values obtained in this study, however, were entirely useful for building the local capacity and might not be comparable to values reported elsewhere.

Variations in terms of volume, as seen in Fig. 2, show that organic waste and cardboard were the two fractions that made up the bulk of the solid waste with averages of 110 L and 75 L, respectively. The third constituent in importance in terms of volume was plastic bags, which was 30.7 L, that is less than one-third of the organic waste volume. Plastic bottles were the fourth fraction in importance with an average volume of 22.23 L, while mixed paper was fifth with 19.96 L. Wrappers and glass were the next ones in importance with average volumes of 13.05 L and 11.67 L, respectively. Finally, the average volume of glass was <2 L. Transportation is generally of main importance in determining waste volume and hence the compaction activities were useful. Also, it is understood that volumes of different fractions cannot be summed to determine the total volume of waste since small components of waste can occupy voids created by the larger com-

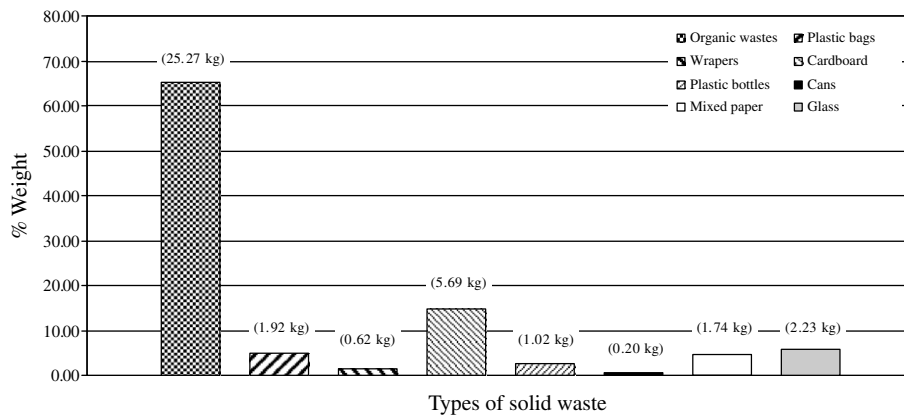


Fig. 1. Average weight of solid waste expressed in percent and mass (kg); wastes collected and classified at the demonstration site in San Mateo's market between June and August 2003 ( $n = 6$ ).

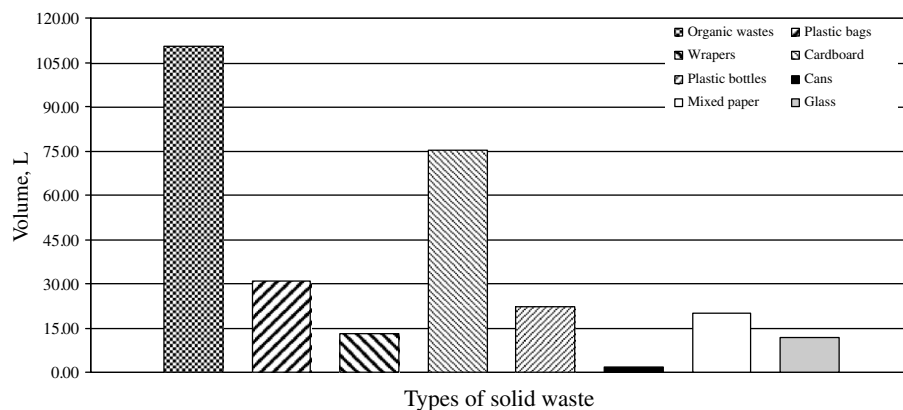


Fig. 2. Average volumes of solid waste collected and classified at the demonstration site in San Mateo's market. Wastes generated on market days during the period June–August 2003 ( $n = 6$ ).

ponents when mixed together. In this study, volume determinations helped in educating members of the working team on density determinations and data interpretation, and in better understanding the importance of compaction through observations of volume reduction during their hands-on activities.

Members of the working team learned how to use data of weights and volumes to determine densities. The latter helped them in interpreting data on waste densities and in understanding the weight/volume relationship most commonly used in SWM. It was clear for them, at the end of the study, that waste of relatively large mass and small volume will have a relatively high density. The best example was the density determination of glass; having the third largest average weight (see Fig. 1) but the second smallest volume (see Fig. 2) made this fraction the second in importance, after organic waste, in terms of density (see Fig. 3).

The density of organic waste averaged  $0.23 \text{ kg L}^{-1}$  and was frequently the densest solid waste constituent as can be seen in Fig. 3. Glass, as mentioned above, was the constituent that frequently had the second highest density; it averaged  $0.20 \text{ kg L}^{-1}$ . The weight/volume relationship of cans made them the constituent with the third largest density; its average was  $0.10 \text{ kg L}^{-1}$ . The rest of the constituents, including cardboard boxes, had densities lower than  $0.09 \text{ kg L}^{-1}$ .

It is important to take into consideration that the variation of solid wastes densities within fractions was probably affected by differences in ash, dirt, and moisture content, which added weight to the waste. In San Mateo Ixtatán, burning solid waste containing mixed paper was a common practice, and it produced ash. Dirt in the solid waste came from the soil while sweeping and collecting waste initially disposed on the floor of the market. The origin of moisture was mainly rain; however, some people watered the soil before sweeping or added wastewater on the soil after washing hands or utensils. The density of cardboard boxes varied the most, and this was probably caused by differ-

ences in moisture content due to frequent rain events in San Mateo Ixtatán.

Average weight, volume, and density of organic waste were always the highest and made it the principal constituent of solid waste collected at the selected dumpsite after market days in San Mateo Ixtatán. However, great variations occurred during the time data were collected. For example, the weight of organic wastes averaged almost 25 kg and increased gradually from about 7 kg on June 19 to approximately 50 kg on July 28, then decreased in August to levels lower than 20 kg (see Fig. 4). Residues of fruit and vegetables made most of the organic waste; fruit wastes were mainly banana peels and apple cores, while vegetable wastes varied. Emphasis was put on that organic waste data because, as mentioned above, people in San Mateo Ixtatán practiced composting. It made them realize their important contributions to the reduction of both the mass and volume of organic waste.

These variations in volume for organic wastes followed a similar pattern of its weight variation. Volumes gradually increased from 59 L on June 19 to 235 L on July 28. All measurements of organic waste volumes during August showed a decrease and were lower than 100 L as can be seen in Fig. 5. The higher values for volume corresponded with the predominant abundance of cornhusks in the organic waste while the lower values corresponded with the abundance of fruits and vegetables of sizes smaller than cornhusks. Sub-classification or sub-fractionation of organic wastes was performed on two occasions for demonstration purposes only. That activity did not involve quantification activities; thus neither weight nor volume measurements were taken. However, those activities confirmed the variability of vegetable wastes and provided the members of the working group with ideas and skills that they can use during the planning and implementation of composting activities.

Variations of densities for organic waste corresponded with variations in weight and volume throughout the period when data were gathered, as shown in Fig. 6. These

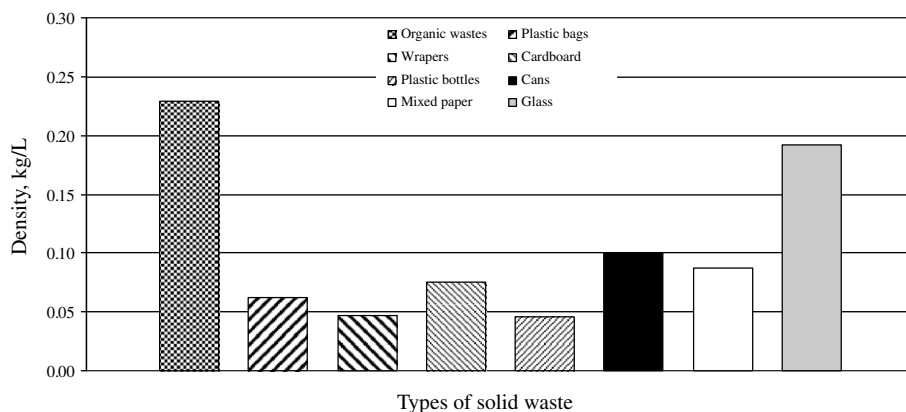


Fig. 3. Average densities of solid waste collected and classified at the demonstration site in San Mateo's market. Wastes generated on market days between June and August 2003 ( $n = 6$ ).

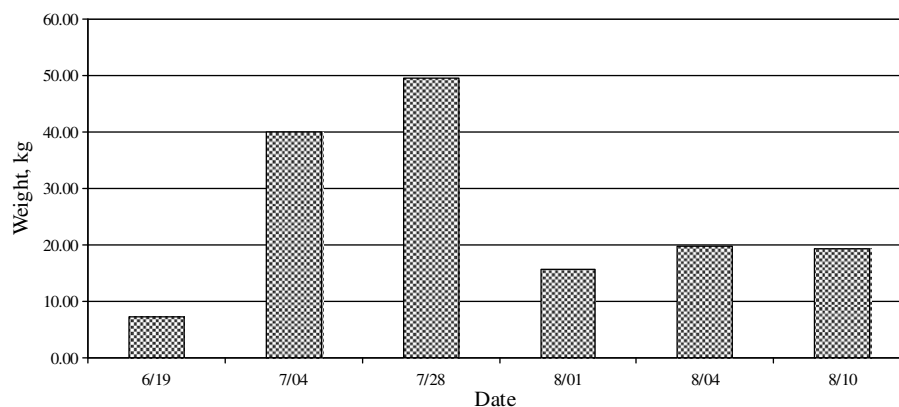


Fig. 4. Weight variation of organic wastes, the main constituent of waste in San Mateo's market. Wastes were collected and classified by members of the SWM program working group.

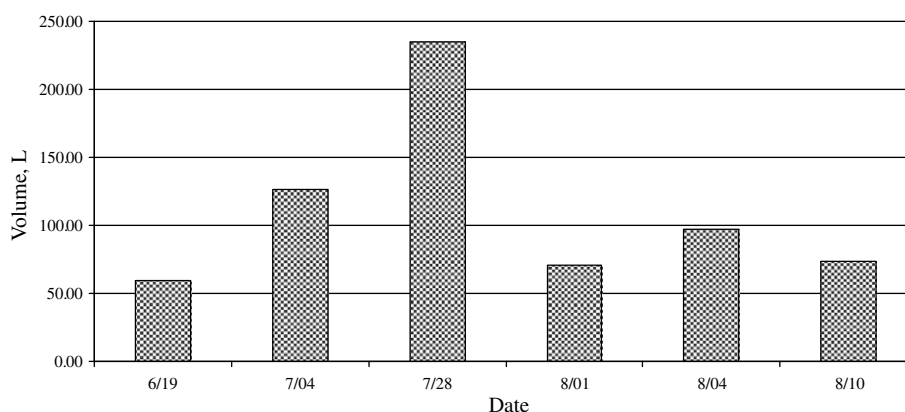


Fig. 5. Volume variation of organic wastes, the main constituent of waste in San Mateo's market. Wastes were collected and classified by members of the SWM program working group.

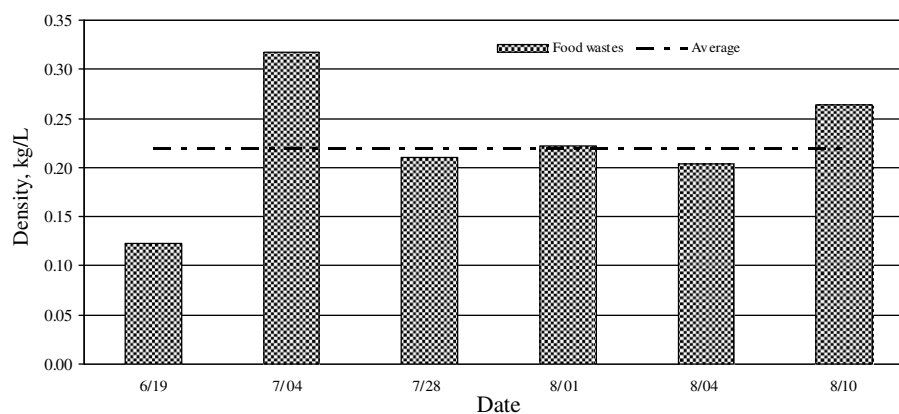


Fig. 6. Density variation of organic wastes, the main constituent of waste in San Mateo's market. Wastes were collected and classified by members of the SWM program working group.

variations ranged from 0.12 to 0.32 kg L<sup>-1</sup> and averaged 0.22 kg L<sup>-1</sup>. Densities were higher than the average on July 4 and August 10, days that corresponded with relatively low determinations of organic waste volumes.

Density variations for organic wastes can be explained in terms of variations of both weight and volume. Weight

variations in organic wastes could be associated with two factors, moisture content due to external water sources and moisture content due to type of waste. Volume variations in these wastes could also be associated to two factors, which are void content and resistance to compaction. The occurrence of low densities in organic



wastes can be explained through the case of corn, a top agricultural product in Guatemala, which was sold in the market of San Mateo. Cornhusks were the main constituent of organic wastes. Taking into account that the volume of voids in cornhusks can be large and that they are relatively resistant to compaction by hands and feet, large volumes of wastes containing husks can be expected. Further, cornhusks gain very little moisture from external sources due to their impermeable surface. Also, their own moisture content is relatively low. Thus the weight/volume ratio is expected to be small. In comparison, the occurrence of high densities in organic wastes in San Mateo can be explained by the presence of citrus and pulp-containing fruits, and banana skins as their main constituents. Those constituents contain a smaller volume of voids than cornhusks, and the voids volume can be reduced by compaction using hands and feet. Also, they have large moisture contents and moisture from external sources can be better retained, which will result in a large weight. Thus the weight/volume ratio is expected to be larger than the one for cornhusks, and it could help explain the two densities larger than the average found among the six samples.

## 4. Conclusions

### 4.1. Short-course

The short-course was successful in educating students and the community on the basic principles of SWM. The support that community members showed to the public health action plan was best manifested through their growing participation in the course. The initial number of students increased by almost 50% prior to its finalization, when a normal trend is that the number of students would drop. The basic concepts learned during the theoretical part of the course were put into practice during the hands-on activities, and the majority of students were able to remember and use terminology learned in the course. An important link to each one of the public health aspects that people were interested in addressing (drinking water quality, solid waste management, and wastewater management) was the local representation of the water cycle. The water cycle was useful while teaching the course and during the conduct of the sanitary surveys.

### 4.2. Hands-on activities

Activities carried out during the public health action plan designed for San Mateo Ixtatán considered the complete SWM cycle, from the reduction of waste generation through the final disposal. In addition, if a SWM program or strategy is going to be sustainable, it must consider environmental, economic and social aspects. If people who generate waste (i.e., the general public) are not included in the decision-making process and most importantly in designing an action plan, this could threaten the sustainability of the program or strategy. The strength of this project is that we

avoided that problem by including the key people in the decision-making processes and throughout the conduct of the study.

### 4.3. Networks of collaboration

The networks created with municipal authorities and representatives of national and international organizations working locally appeared to give members of the community a sense of empowerment. The indigenous groups of Guatemala have been victimized and marginalized for years. Thus it is important to consider the impact this has on communities and individuals when trying to build local capacity. In this setting, building capacity by including the community in the decision-making process and in designing and implementing the action plan was necessary and unavoidable. At the international level, the Director of The Ixtatán Foundation, the institution funding the public health action plan, contacted academics at the University of Virginia, Charlottesville to begin another project linked to the implemented SWM program.

### 4.4. Building local capacity

The initial effort in building local capacity for SWM in San Mateo Ixtatán was completed. The short course and hands-on activities educated members of the solid waste working group on the basic principles of MSWM. The application of social capital principles and the willingness that local people had to tackle problems associated with solid waste mismanagement facilitated the fluid interaction between community members and the team leading the implementation of the solid waste management program. Data gathered were very helpful for people to realize the importance of classifying and quantifying waste prior to its transportation and final disposal. This was relevant because municipal officials started to use the new temporary dumpsite for disposal of solid waste collected near the market and downtown using the mayor's truck. Thus the community and municipal officials acknowledged the importance that the weight/volume relationship had in implementing and developing the MSWM concept.

### 4.5. Challenges

Nevertheless, two main challenges were found in this effort. The first was the lack of long-term commitment from the local authorities, the technical experts, and the regional and national government to sustain the SWM program. The second is the need for solid funding in order to keep a program running in the absence of governmental resources. An example that illustrates those challenges is the situation of recycling in Guatemala. The only recycling facilities that exist in the country are located in Xela or Guatemala City, which are far away from San Mateo Ixtatán. Thus recycling was not an option because of the distance and the cost of transportation for a small volume

of recyclable materials. Recycling may become important in the future if a closer recycling facility is built, perhaps in Huehuetenango, the department's capital city, but it will demand political will and commitment.

Nevertheless, the experience gained during the development and implementation of the SWM program in San Mateo Ixtatán can be replicated in similar communities in Guatemala and elsewhere. Also, the lessons learned can be used as guidelines for the design of future comprehensive interventions.

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